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Results of the yields of these lines for one year are considered only as indications of what may possibly be expected from them over a three-year period at different locations in the state. In 1000 seed weight they were higher than Redwing but not equal to Bison. Each one of the lines equaled or exceeded Redwing in iodine number of its oil. In wilt resistance each of the five lines exceeded the parents, Redwing and Bison.

Summary

Minnesota has produced since 1901, except during the war period, about half a million acres of flax annually.

The introduction of the variety Bison brought an oil quality problem. However, Bison has proved so valuable a variety in other respects that it has become the leading variety grown on farms in the state.

Linkage between low weight per 1000 seeds and high iodine number was found to occur in segregates from the crosses Bison x Redwing and Bison x Common Pink. This has made difficult the recovery in the hybrids from these crosses of individuals in which was combined the medium large seed size of Bison and the high quality of oil of the other parents.

In segregating families of the cross Redwing x 770B, the individuals with yellow seeds averaged considerably higher than those with brown seeds. Linkage between seed color and iodine number was determined by the X^2 for independence test.

Segregation of individuals in hybrid material from the cross Redwing x 770B in the ratio of three low to one high in iodine number of the oil has been shown by the X^2 test.

Lines have been selected from the crosses Bison x Redwing and Bison x Common Pink which equal the high iodine parents in quality of oil. None of these lines is equal but some of them approach to Bison in seed size.

DROUGHT RESISTANCE OF GREEN ASH AS AFFECTED BY GEOGRAPHIC ORIGIN

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The Shelterbelt project has greatly stimulated interest in tree planting in the Prairie-plains region. Obviously trees which are to be planted in this region must possess a high degree of resistance to drought if they are to survive and form a protective barrier against wind. It, therefore, becomes a matter of prime importance to collect

[1] Maintained by the United States Department of Agriculture, St. Paul, Minnesota, in cooperation with the University of Minnesota.

seed and grow seedlings for such planting from parent trees known to be drought resistant.

One of the most promising trees for shelterbelt planting, and one which is widely used because of its apparent resistance to drought, is green ash.[2] In this study an attempt was made to determine the influence of climate and site conditions in developing heritable drought hardiness of this species by testing artificially the drought resistance of plants grown from seed of different sources. The present study deals with tests of resistance to artificial drought by progeny of 83 individual green ash trees distributed over 39 stations within and adjacent to the shelterbelt zone.

Stratified green ash seed from the different sources were sown in tin containers of uniform sandy loam in the greenhouse. During the interval of growth prior to testing certain variations among the seedlings were recorded. Seed from the northern areas characteristically showed slow germination and growth. The plants produced were also much smaller and had darker green foliage than the trees from the south. In one series, which received very little sunlight during the winter months, the northern plants appeared to be approaching dormancy at the time of testing. These traits are evidently due to inherent characteristics which have been acquired through long generations of natural selection.

A preliminary laboratory test gave some indication that drought resistance of green ash was greater in the north than in the south. Since this was an encouraging stimulus, it was decided to divide the plants into several different geographic sources, Figure 1. This was accomplished by arbitrarily dividing the region into ten parts: longitudinally into east, central and west portions, and again divided latitudinally into north, central and south portions. The northwest section is further divided into an east and west portion. Such an arrangement also facilitated a study of the differences in climate. Several of the factors affecting the climate of these subdivisions are shown in Table I.

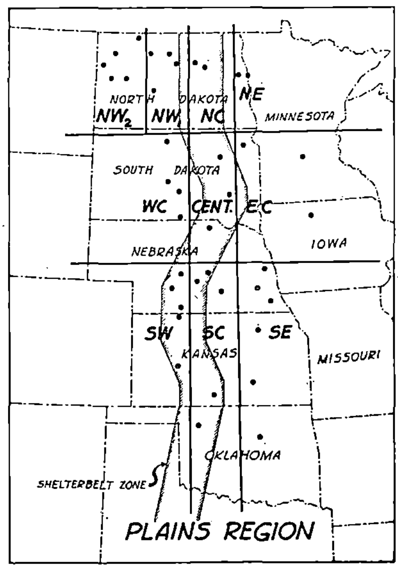

FIGURE 1

[2] Due to disagreement among taxonomists, prairie ash *(Fraxinus campestris Britt.)* and green ash *(F. pennsylvanica lanceolata (Borkh.) Sarg.* have been placed in a single group and for the present will be referred to as green ash.

The Plains region has a great variation in climate. The average monthly precipitation[3] varies from 1.2 inches in the extreme northwest to 2.4 inches in the southeast. Evaporation also increases from north to south and to a large degree offsets the advantage of increased precipitation in the south. Consequently a close correlation between total rainfall and drought resistance should not be expected.

It must be remembered that climate is conditioned by a number of interacting factors no one of which may properly express the severity of drought which must be endured by vegetation. The one which appears most nearly to express drought severity for the Plains region is the average number of days between rains of substantial proportions. For example the number of days interval between intensive rains of two hours or less duration in the northwest is almost four times as great as in the southeast. This factor is, therefore, used to bring out the relationship between resistance of green ash to artificial drought and the actual climate of the locality from which the seed was collected.

CLIMATIC CHARACTERISTICS OF THE PLAINS REGION

QUANTITY MEASURED	PLAINS REGION									
	NW_2	NW_1	NC	NE	WC	CENT.	EC	SW	SC	SE
TOTAL PRECIPITATION (AV. INCHES PER MONTH)	1.2	1.3	1.4	1.7	1.4	18	21	16	20	2.4
EVAPORATION (AV. INCHES PER MONTH)	57	5.7	48	4.8	6.2	6.2	48	7.4	7.5	75
RAINFALL FREQUENCY NO. DAYS BETWEEN INTENSIVE RAINFALLS	107	83	71	55	81	55	42	60	38	31

TABLE I

The plants from the different subdivisons of the region were then subjected to drought tests. For these tests a simple drought chamber was constructed of large storm windows within which the seedlings were exposed to controlled "climate," simulating extreme drought conditions. A uniform radiation intensity of .22 gram calories per square centimeter per minute was maintained within the chamber by means of 300 watt lamps in reflectors placed 12 inches above the plants. These lamps, together with two thermostatically

[3] Due acknowledgment is made to the U. S. Weather Bureau for information made available on climate of the Prairie-plains region.

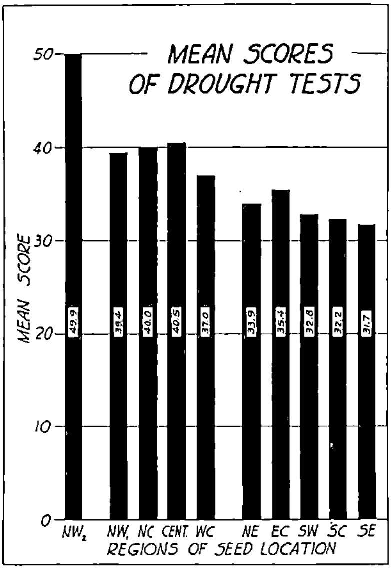

FIGURE 2

regulated heating units, provided a temperature of 108 degrees Fahrenheit. A desiccating air current was obtained by blowing the air over trays of calcium chloride by means of three electric fans. The air passed over the plants and beneath the slightly elevated platform on which they stood. The plants were shifted daily to insure uniform exposure to the slightly greater wind velocity near the fans. Complete records were kept of the size of the seedlings, the number and color of leaves for each plant, their length of life in the drought chamber, and the order of their death. The first plant to die was assigned the number "one," the second "two," and so on. The figure obtained by averaging the numerical order of death for the trees of a given regional subdivision is called the mean score. These scores are used as criteria of drought resistance. The mean scores presented in Figure 2 are averages of two separate experiments, each of which consisted of four identical tests, on plants from all subdivisions of the region.

The gross differences in drought resistance of trees from individual regions are not great, but a definite decrease in resistance is noticeable from north to south, and from west to east (Fig. 2). The greatest difference was found to be between the southeast and the northwest areas which had mean scores of 33 and 50, respectively.

Using the mean score and the length of intervals between rainfalls respectively as the bases for comparison there appears to be a definite correlation between the drought resistance of green ash and the drought areas of the Plains region (Fig. 3). In group-

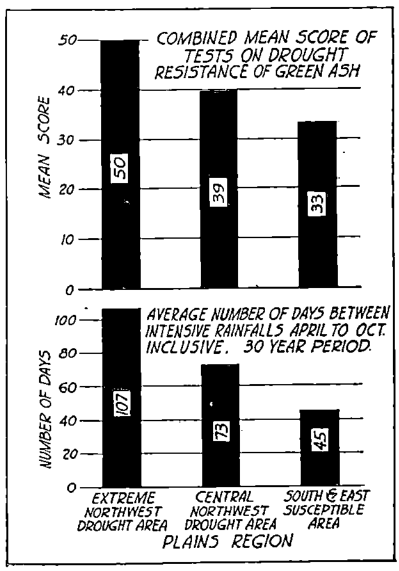

FIGURE 3

ing the data, the western half of the northwest area was selected as the individual section showing the most drought resistant seedlings. All eastern and southern sections, which had comparable low mean scores, produced green ash most susceptible to drought. The four remaining northern, western and central areas, produced ash intermediate in drought resistance.

Using the analysis of variance methods of caculating these data, the individuals within each of these three sections were shown to be homogeneous and the differences between the three sections statistically significant.

These variations within the green ash of the Prairie-plains region constitute evidence of the existence of climatic races whose character differences are inherited by their progeny. Pure lines probably do not exist within individual regions, because extraneous variables such as soil types, topography, and other factors favor an intergradation of characters. Because of this, it cannot be said that seed from the southeast will not grow when exposed to the more severe climatic drought existing in the northwest. The overlapping of characters within climatic races may permit some such seed to grow and survive the rigors of climate peculiar to that region to which it has been transferred. It does not mean, however, that such promiscuous use of seed from southern areas for planting in localities of more severe drought is a good practice to follow. The probability of securing a poor stand is much greater than if the seed had been obtained locally or from areas of like severity of drought. The data are sufficiently convincing to indicate that in general seed from the north and northwest regions should achieve a slow but hardy growth in any of the other regions, as far as drought is concerned. From observations on the slow germination of northern seed and the slow growth and early dormancy of its seedlings, there is the likelihood that these drought resistant races would also be immune to frost injury in the southern regions. However, a considerable sacrifice in the rate of growth would undoubtedly occur should such a transfer be made.

The importance of using proper source of seed in forest planting can scarcely be overemphasized. This fact has been substantiated in several European countries where the importation of seed has been subjected to rigid governmental supervision in an attempt to prevent further introduction of poorly adapted races. There is every reason to suppose that forest tree species contain as many climatic and edaphic variants as exist in agricultural crops.

An intimate knowledge of forest trees in relation to racial variants is an essential requisite for guiding large-scale forestation programs. Knowledge of soil and climatic requirements, together with physiological tests should be applied to obtain the best results from forest planting. The results of this study indicate the value of such methods for determining climatic variations within species and furnish guiding evidence for selecting seed best suited to a given region.